Fostering Transformative Experiences for Construction Students: Gamifying a Surveying Course

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A transformative experience happens when a student is able to use knowledge learned in the classroom and connect it to an observation or experience outside of the classroom. This connection of classroom subject matter to an everyday experience enables the student to more fully understand the concept and results in increased learning. Gamification is the process of adding game elements to a non-game scenario. Gamification is used by business, marketers, and educators to increase the engagement and involvement of consumers, employees, and students. This paper presents a case study of the use of gamification in a Construction Surveying course. The authors use this case study to discuss the importance of transformative experiences and how gamification can be used as one tool to foster them.

Key Words: Construction Surveying, Gamification, Transformative Experience, Motivation

Introduction

For many types of problem-solving, learning happens more richly by doing (Anzai & Simon, 1979). This is particularly true of learning in construction education due to the rich hands-on characteristics of the construction industry. Educators are tasked with creating an engaging educational experience to foster the knowledge and skills required to be successful in society. This must be done with a limited number of tools to create a learning environment that encourages students to engage in meaningful learning, which in turn will enrich and expand the students' everyday experience. The purpose of this paper is to investigate the role of transformative experiences to create this type of learning environment. We will also extend this discussion to how gamification may foster transformative experiences for students at the post-secondary level.

Literature Review

We have all seen or experienced some form of gamification in our lifetimes. One of the first places you probably experienced a gamified situation was in the classroom. When the teacher had you play the *quiet game* as a respite in the classroom, you were participating in a game. This game represented a contest for students while teaching the valuable life skill of self-control in the process. Gamification is best defined as the use of game elements in a non-game context (Deterding et al., 2011). This definition leaves the concept open to a vast array of possible formats and methods. The model on which we focus resembles the video game format. With any goal oriented activity there must be some reward mechanism to foster competition, track progress and in turn increase motivation and engagement (Glover, 2013). Technology has allowed this idea of gamification to become much more sophisticated and less demanding for the educator.

Gamification has been used successfully used to foster engagement in various activities. The widely used mobile application FourSquare is encourages users to connect with one another and 'check-in' to locations. The user with the most check-ins at a location over a time period is named the mayor of the location (Glover, 2013). This is an example of using social networking to track and compare progress and give rewards to high achievers. The Boy Scouts of America also uses gamification through the use of merit badges to reward participants who complete identified tasks. A scout earns new levels or ranks based on earned merit badges (Deterding, 2012). This reward mechanism encourages the participants to engage in tasks and challenges while tracking progress with the ultimate goal and reward of achieving the rank of Eagle Scout.

In the classroom gamification is used extensively at the elementary and middle school levels.   An entire public school in New York City has gamified its system. Quest to LearnTM (Q2L) gamified its curriculum when they opened their doors in 2009 because they believed that various disciplines such as language arts, math, science, and so on could be taught as a type of game (O'Keefe, 2012). Q2L has incorporated levels, quests, missions, and incentives into the overall learning process and has created worlds where learner–players assume behaviors and identities such as explorers, historians, and writers who seek to solve difficult problems and seek knowledge while receiving feedback and considering others' point of view.

Although it can be a valuable tool, gamification is not a panacea. Hanus and Fox (2015) attempted to assess the effects of the gamified classroom by comparing a traditional classroom to a gamified classroom. The gamified classroom consisted of eighty college students and used points, badges and leaderboards as the reward mechanisms. A leaderboard was visible to all students based on points received and badges were awarded for completed tasks. The authors concluded that the results of the experiment suggested a negative effect on the classroom specifically with the badge system. They suggested that a better approach may involve other elements of gamification to encourage cooperation among learners rather than encouraging them to compete.

The most commonly used and recommended game elements for gamified contexts are those that allow users to track their progress, feel a sense of progression, and compete with peers. The most common tools for these are points, badges, and leaderboards (Deterding, 2012; Dicheva et al., 2015; Seaborn & Fels, 2015). Users earn points as they accomplish various tasks within the gamified system. Badges, which are distinct awards or trophies, are earned by users for accumulating requisite points or for certain achievements (Denny; 2013). Leaderboards are typically based on points and allow users to track how they are progressing in comparison to their peers which can motivate achievement and a sense of competition.

It is important to note that game elements do not happen passively nor does their effective use. Gamification requires intentional planning as part of the instructional design process with clearly defined goals. Using tools such as points, badges, and leaderboards to motivate students can result in increased student engagement and in turn deeper learning (Hamari, Koivisto, & Sarsa, 2014). The goal of a gamified class should have clear goals with the game elements designed to be used for specific outcomes.

While engagement in the classroom is critical, continuing the learning outside of the classroom is vital to deep understanding. The widely used educational initiative known as Common Core breaks up knowledge acquisition and understanding into five categories. The highest level occurs when a student can bridge the gap and use the skill or content in other subject areas (Porter et al., 2011). Students that interact with material more than once and in different contexts are much more likely to have those break-thru moments. Those light-bulb moments are pivotal in the educational journey of a student. Universities strive to create a love of learning and in turn a lifelong learner. The goal of gamification is engagement. The goal of engagement is to create a new way of thinking, a life changing moment in which a student's actions and view of a subject will be forever changed – a transformative experience.

Pugh (2011) describes a transformative experience as a particular type of learning outcome. A transformative experience is defined as "a learning episode in which a student acts on the subject matter by using it in everyday experience to more fully perceive some aspect of the world and finds meaning in doing so" (Pugh, 2011, p. 111). These transformative experiences range from simple to complex depending on the subject matter and the participant. It can be as simple as recognizing that her bicycle is made up of the shapes she learned about in school or as profound as a high school student developing a deep interest in bird watching after learning about Darwin's study of finches in the Galapagos Islands (Pugh et al., 2010). In this case both individuals are bridging the gap from conceptual to experiential. Therefore, their everyday lives are enriched and expanded through these transformative experiences. The process of constructing new knowledge and appropriating new interpretations of an experience and how it connects to classroom knowledge is explained by transformative learning theory (Taylor & Cranton, 2012).

There have been numerous philosophic and scientific papers written on the importance of the transformative experience as a learning construct (Edmonds-Cady & Sosulski, 2012; Ballestas & Roller, 2013; Batey & Lupi, 2012). Yet, there is not defining research on how teachers can create these transformative experiences. Although the importance of transformative experiences is clear, educators and researchers "do not know how common transformative experiences are or why some students may engage in transformative experiences while others do not"

(Pugh et al., 2010, p. 2). As we reviewed the literature on transformative experience it became clear that the success of this construct was heavily dependent on motivation. More specifically, participants in various studies who were intrinsically motivated reported transformative experiences at a higher rate than those that were not.

According to Pugh (2011), a fully realized transformative experience must meet three prerequisites, "(a) acting on an idea (i.e., engaging with concepts as ideas), (b) experiencing an expansion of perception, and (c) developing a value for the content and the experience it affords" (p. 111). This begs the question, what motivates a student to engage, expand and develop? Motivation is classified as intrinsic or extrinsic. Intrinsic motivation is driven by internal satisfaction. The student would complete the task because they understood and desired some personal satisfaction that cannot be seen. Deci and Ryan (1985) define intrinsic motivation as engaging in a task because it is found to be inherently interesting or enjoyable. A student's curiosity about a subject can foster intrinsic motivation. On the other hand, extrinsic motivation is driven by external rewards. When extrinsically motivated, an individual will engage in an activity for the purpose of obtaining an outcome or achieving a goal that is separate from the activity itself (deCharms, 1968; Lepper & Greene, 1975). Grades in school are a very common form of extrinsic motivation. Young students need to be extrinsically motivated in all areas of their lives. A middle school student may begin reading a book just for the gold star or the fancy bookmark they will receive once they finish. If the book offers the student an adventure or love story which catches the young person's attention, the motivation to finish the book changes from extrinsic to intrinsic.

It is our belief that extrinsic motivation, if utilized properly, can foster intrinsic motivation and in turn allow students to undergo these transformative experiences. Gamification within the classroom is simply an attempt to use games to extrinsically motivate a student, which offers the profound potential for students to gain new levels of understanding and appreciation about a concept. This new understanding and appreciation will, in theory, foster intrinsic motivation and, in turn, allow for transformative experiences.

The purpose of this paper is to describe how gaming elements were used in a class to foster increased engagement in and out of the classroom. This increased engagement outside of the classroom led to an increase in transformative experiences by students in the class

Context for the Case Study

The context for this case study is a semester-long Construction Surveying course at a midwestern university in the US. It is a junior level course that is required in the Construction Science curriculum. One of the purposes of the course is to align with the student learning outcome of the program's accrediting body, the American Council for Construction Education. Specifically, it aligns with student learning outcome #11 which requires evidence that students can "apply basic surveying techniques for construction layout and control" (ACCE, 2017, p. 10). The course objectives are: 1) learn to setup and use a tape, builder's level, total station, and GPS for simple building layout, 2) learn basic vertical building layout functions, 3) learn basic horizontal building layout functions, and 4) understand the importance and use of related field documentation.

There were 22 students enrolled in the class examined and of the students enrolled, 18 of them participated in the gamified system which was optional. The course took place in the fall semester and has both a lecture and lab component. The elements of the gamified system in the class were designed to supplement both the lecture and lab portions of the course but the primary goal was to enrich the lab experience. The reasoning for this was that the tasks associated with the game happen outside of the classroom and help to foster connections between real world applications of surveying which aligns well with the hands-on lab. The expectation was that enriching this portion of the course would in turn enrich the classroom lecture portion.

Method for Instructional Intervention

On the first day of the semester, students in the class were introduced *The Surveying Game,* how it would work, and that that their participation in it was voluntary. Each element of the game was designed to encourage engagement in tasks outside of the classroom to increase engagement in the class. Completion of tasks led to rewards – the rewards being the extrinsic motivators that would hopefully lead to a sense of intrinsic motivation to learn the course content.

The game elements were designed to allow students to track their progress, earn intermediate rewards, and endeavor for multiple larger rewards as goals. This was accomplished through the use of a point system to track overall progress, by use of achievable ranks, with physical tokens to represent progress and achievement, and with a reward system. A leaderboard was not included in the case study as there was some concern regarding privacy regulations.

The foundation of the game was a system of earning points by completing tasks. The tasks were designed primarily to be done outside of the normal class context. The one exception was earning points for watching a series of videos that have been used in the course in lieu of a textbook for the past several years. This is in keeping with the concepts of a flipped classroom by moving the basic learning outside of the classroom and using the lecture period for deeper explanation of the topics. The video-watching tasks were not enough alone to earn any rewards but could be used as a supplement to the primary focus which was interacting with how surveying is done in the real world. Tasks were grouped into categories and were worth various point values for their completion. Some examples of tasks are:

- Uploading, to the class discussion board, a photo of a crew using equipment with a description of the equipment and the purpose it serves. The experience of seeking out equipment used while situated in its context and describing it to classmates helps to connect concepts from the classroom with how they are carried out in the industry.
- Uploading a photo of surveying objects, monuments, or landmarks they have found on campus or around town with a description of where they found it and how it might be used. The experience of searching for landmarks and then describing them to the class is helpful in solidifying a description from class into how an object looks and is used in the real world.
- Interviewing a surveyor and posting a summary of the interview. This personal interaction helps the students to transform their notion of what a surveyor is and does into a concrete example of the day-to-day experiences of a surveyor. It also gave them some tips and tricks of the trade that are more meaningful coming from a working practitioner.
- Reading an article about a surveying topic not covered in class ad posting a summary. This search for additional knowledge that was not covered in classroom discussions helps to make additional connections for the students. Their article summaries are a way to connect what they have learned with course content in new ways that are tailored to their own personal experienced.

The points that each student earned were tracked as they completed various tasks. The points allowed them to advance in rank within the game. The available ranks were *Noob, Apprentice, Journeyman,* and *Jedi Surveyor*. The advancement in rank was important because each new rank opened up eligibility for a new set of rewards. Every participant began as a *Noob* and only those that achieved the *Jedi* rank were eligible for the top tier of rewards. The advancement in rank was tied directly to points accrued with automatic advancement each time a predetermined point total was reached.

The students were also given physical tokens, shown in Figure 1, as they earned points and completed other tasks. They received a token (either valued at one or five points) for each point they earned and could also earn points for achievement in the lab activities. Students could earn additional tokens for using a particularly unique process in the lab or for being declared the winning group in a lab session that was set up as a competition for accuracy or speed. Only the points earned enabled advancement in rank since they were tracked more closely but tokens were used to redeem for rewards.

Figure 1: Front and Back of a 5-Point Token

The rewards were of varying value and their cost in tokens varied accordingly. Some of the rewards were fitting on an individual level (such as ones based on individual grades) and others were fitting at a group level (such as use of additional equipment during lab), namely for the trio of students working together during the lab exercises. While students were encouraged only to pool or otherwise trade tokens when redeeming for group rewards, this was not policed closely. The rank system to become eligible for higher tiers of rewards removed the benefit of trading tokens. Some of the rewards that tokens could be redeemed for were:

- Early access to lab assignments for planning purposes.
- Use of additional tools or equipment in the lab.
- Use of more advanced equipment in the lab, such the GPS system, earlier than other groups.
- Getting a hint on an exam question during the exam.
- Receiving points back on an exam.
- Being exempt from taking the final exam.

Other similar studies have focused on the role of the transformative experiences in learning. For this study, we wanted to look at how these transformative experiences are an overriding influence on learning and motivation. The goal for this study was to use gamification to create extrinsic motivators that could lead to participants being intrinsically motivated for the task. The process of carrying out the tasks has the potential to produce transformative experiences and thus deeper learning.

Student Response to and Participation in the Game

The students that participated all responded positively to the experience. When polled at the end of the semester about their perceptions of the class game, most students reported that they expected it to be a fun element but were slightly concerned that it would just be something extra to do. They also reported, however, that the opportunity for various rewards was enough of a motivator to get them to participate in the game. While the sample size was small, the average final grade for those who participated was four points higher than those that did not. Additionally, the class average was nine points higher than the previous year when there was no gamification. The significant number of interactions on the discussion board were indicative of the fact that the experiences were indeed transformative and that they were connecting the classroom content to things outside of class.

There was consistently high engagement among students in the tasks that happened outside of the classroom and lab environments. Although there was considerably higher interaction with the textbook videos than in previous years, the tasks outside of class proved to be the most popular way that students chose to earn points. There were several students that would come up with ideas for tasks that could be done and submit requests, per the process specified in the game description, for tasks that they would like to complete outside of class.

Interaction on the discussion board with students posting photos of equipment and monuments was abundant and many who posted photos received commentary and other feedback from other students. The discussion board also created a system of transparency, encouraging academic integrity. Ten students interviewed at least one surveyor and six interviewed two surveyors. The most common, and most token-costly, reward redeemed for was exemption from the final exam with 14 of the 22 students that participated redeeming a portion of their tokens for this reward. Additionally, since the specified method of grade calculation was to replace the final exam grade for those that chose exemption with the average of their first two exam grades, there was an increased average in the first two exam grades compared to previous years. It is likely that they worked harder to study for the first two exams so that the grade would be counted for the exams themselves and for the final exam grade for which they were working toward exemption. The other most common rewards sought were the use of additional equipment during the labs and receiving partial credit points back on exams.

Limitations

Since this was a case study using only a single case, the largest limitation is the small sample size. While the effects of the gamified system are compared to previous iterations, there was no controlled experiment to make more

scientific comparison of the treatment and non-treatment groups. Additionally, it is difficult to measure a transformative experience. The only method used is when a student reports undergoing a transformative experience. Therefore, we had to infer when transformative experiences were indeed occurring based on interactions with students, by observing interactions between students, and by observing the learning that had taken place.

Results

The primary result of the gamified system was increased activity by students and interaction with surveying tools, equipment, people, and concepts outside of the classroom and lab. These activities of interacting with real-world uses and implementations of concepts learned in the classroom served to deepen the learning experience. These transformative experiences were crucial in enriching the learning in the class. For example, one student found the City's map of elevation benchmarks and posted it to the discussion board with a description. This student later described how finding this helped him to better understand how the surveying activities on a single construction site are connected to the activities outside the site. This light bulb moment was a classic example of how a transformative experience enhances learning.

Similar to a flipped classroom, many students engaged in the baseline material before class so that the higher-order problem solving could be done during the class period. While this was not a stated goal of the gamified system, and it was not a fully flipped classroom, it was an unexpected benefit.

The game elements used, as suggested by the literature, were effective in fostering motivation among the students. The accumulation of points and the ability to track progress toward a goal led students to participate more. The ability to earn badges by increasing in rank and earning tokens allowed for a simple tracking of progress and comparison to peers. The rewards were the biggest motivator that served as the foundation for all the other elements. Although the public leaderboard was not used in this class, the current iteration of the class has leaderboard and has seen increased participation, even from the very beginning. To avoid FERPA violations, leaderboards can easily be disconnected from any actual grades and made anonymous with pseudonyms.

The physical tokens appeared to be a motivator as well. There was a delay in the manufacturing and shipping of the tokens so they weren't distributed for the first time until after the third week of class. Once there was a physical means to track progress (students would commonly stack their tokens on their desks, particularly during exams) there was a motivator to earn more. After the tokens were first distributed, there was an immediate spike in how many students participated and how much they participated.

With the ultimate goal of the gamified system being increased engagement and learning, the system was effective. The grades in the class were higher than the five previous iterations of the course taught by the same instructor. Things such as frequent requests by students for opportunities to do extra work that they could do outside of class for points was indicative of the degree to which the students engaged with the material and suggests that the extrinsic motivators that were part of the game led to students being intrinsically motivated to do the tasks related to the surveying content. The increased engagement through participation in the game resulted in transformative experiences and deeper learning.

Recommendations for Using Gamification in the Classroom

A big concern with incorporating game elements into a classroom is that it will be a drain on resources. More time may be required of the instructor to plan the gamified system, to track the student progress, and to manage the reward system. More time may be required of students to participate in the tasks outside of the classroom and to keep up with their own progress toward their desired goals. While the additional time for planning for the instructor was found in this case, it was not significantly higher than the planning that should be done for any course preparation. Good instructional design includes aligning course activities, in and out of the classroom, with the learning objectives. The gamified system should not be made any more complex than aligning activities with objectives, it simply needs a framework for why the objectives. The framework for the game provides additional motivation for students as it fosters students' perceived instrumentality for the activities which is an understanding

that the tasks have value and therefore worth doing (Miller, DeBacker, & Greene, 1999). This alignment with course learning objectives is crucial to ensure that the efforts are well spent.

Any gamified course should take care to use only the game elements that are fitting for the course. While many game elements are possible (Deterding, et al, 2011), not all of them need to be used in every course. For the case study presented here, we used a version of points, badges, and leaderboards but did not strictly adhere to any previously used formula. The principle of game elements, however, were followed so that students could feel a sense of progression, track absolute and relative progress, and have a goal to strive for. Points, tokens, ranks, and rewards – while working within a defined set of attainable tasks – worked well for this case study and variations on it have been successful as well.

The immediate goal of the game for this case study was to foster transformative experiences with an end goal of deeper learning. The real-world experiences brought on by the game activities were the mechanism for these transformative experiences. When setting up a gamified system for a class, the instructor must identify the transformative experiences fitting for the course. While doing a neighborhood scavenger hunt for city benchmark monuments is fitting for a surveying student, an estimating student may talk to an estimator about the logistics of bid day and a soil mechanics student may observe a materials-testing lab test the plasticity index of a soil sample.

The key to successful implementation of a gamified class is not wholly different from the success of any other class. The course learning objectives should be the overriding influence in the development of all course activities. All lectures, homework assignments, quizzes, and exams should point to the learning objectives in any well-designed course. A gamified system is merely a framework to develop course activities that align with objectives and have the added benefit of increasing student motivation.

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